Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 8 Issue 8 August 2024

Research Article

Efficacy Testing of Different Pesticides for The Management of Major Insect Pests of Cabbage

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DOI: 10.31080/ASAG.2024.08.1394

Received: May 21, 2024;

Published: July 26, 2024

Abstract

A field experiment was conducted at Gokuleshwor, Baitadi, Nepal for the management of insect pests of cabbage using synthetic and biological pesticides; Azadirachtin, Cypermethrin, *Bacillus thuringiensis* var kurstaki, cow urine, Jholmol and *Beauveria bassiana* to control major insect of cabbage. These treatments were replicated three times in a Randomized Complete Block Design (RCBD) and the effect of different treatments on the population of major damaging insect's (cabbage butterfly, cabbage semi-looper, and cabbage aphids), number of infested plants, number of damaged leaves and number holes in leaves/plant were recorded. The highest larval populations of cabbage butterfly, cabbage aphids and cabbage semi-looper were recorded in control and lowest number was recorded in Cypermethrin. *Beauveria bassiana* pesticides Racer showed a lower effect than Cow urine and Jholmol in control of semi-looper population. The number of infested plants, damaged leaves and number of holes in leaves/plants were recorded lowest in Cypermethrin. Cabbage head weight and B/C ratio were found lowest in control and highest in Cypermethrin. The insecticides Azadirachtin, Mahashakti (*Bacillus thuringiensis* var *kurstaki*, Racer (*Beauveria bassiana*) and Jholmol would be the best alternative for the eco-friendly management of insect pests of cabbage.

Keywords: Cabbage; Cabbage Butterfly; Cabbage Insects; Superkiller-10 and Eco-friendly

Introduction

Cabbage (*Brassica oleracea* var. *capitata*) is one of the major vegetables of Nepal belonging to the Brassicaceae family and genus of *Brassica*. It is closely related to other cole crops like broccoli, cauliflower, and brussel sprouts [1]. It is one of the most popular vegetables in the world because of its adaptability to a wide range of climatic conditions and soil types, ease of production and storage, and food value. It is an important vegetable cultivated in a 29,638-hectare area with a production of 494,053 tons during 2020-2021 in Nepal. The average production of cabbage in the Baitadi district is 1215 tons with productivity of 13.00 tons/hectare [2]. These vegetable crops can be used to provide a wide range of delicious cooking items in restaurants, including salads, curries, soups, pickles, and many more [3]. The crop has anti-inflammatory and antioxidant qualities, is an excellent source of potassium and manganese and has a detoxifying impact because of its high sulfur and vitamin C contents. It is grown for its edible enlarged terminal buds known as the head, which is a rich source of vitamin A (2000 I.U.), B1 (50 I.U.), and C (124 mg/100gm). Also, it contains minerals including phosphorus, potassium, sodium, calcium, and iron.

There are many limiting factors of cabbage production and insect pests play a vital role in the decreased production of cabbage. Many insect pests damage the cabbage crop (*Brassica oleracea var.*

capitata L.). Among them, Lepidopteran insects such as cabbage butterfly (*Pieris brassicae*), cabbage semi-looper (*Thysanoplusia orichalcea*.), diamondback moth (*Plutella xylostella* L.) and tobacco caterpillar/prodenia caterpillar (*Spodoptera litura* Fab.), are the most destructive insect pests of cabbage [4]. The common insect pests of cabbage in Nepal are cabbage aphids (sucking type), cabbage butterflies, cabbage semi looper, diamondback moths, flea beetle, grasshopper, field cricket, etc. among which cabbage butterflies and aphids are more destructive pests of cabbage. Cabbage aphid *(Brevicoryne brassciae* L.) is one of the major pests of the cabbage and its caterpillars significantly reduces cabbage yield in cabbage growing areas [5]. The first instar caterpillars just scrape the leaves; later on, they eat up leaves from the margins inwards, leaving the main veins only. The young caterpillars of diamondback moth scrap epidermal leaf tissue, producing typical white patches, and the older larvae bite holes in the leaves, the infestation is more severe in the dry season when it causes growth retardation (undersized heads) [5]. Both nymph and adult aphids suck the cell sap from leaves, stems, cords, and inflorescences which results in deformed curly leaves, reduced fruit quality, unfilled pods, and unhealthy seeds [6]. The diamondback moth, *Plutella xylostella* is a serious pest of cruciferous crops throughout the world [7]. The cabbage aphid (*Brevicoryne brassicae* L.) is an important pest of cabbage which reduces the yield and quality of the cabbage head [5].

The control and management of insect pests of vegetables and other crops are primarily based upon the use of insecticides. Currently, the use of chemical pesticides is rapidly increasing and this approach of management has several negative consequences on both the environment and people [8]. Pesticides are usually understood by Nepalese farmers as a weapon for managing pests. The use of chemical pesticides causes various harmful effects on human beings and the environment [9]. According to [10], there have also been long-term observations of chemical pesticide effects on soil, the environment, human health, groundwater contamination, pesticide resistance, insect resurgence, and other ecological repercussions. Similarly, the cost of inputs for growing vegetables might go up as the cost of chemical pesticides goes up, resulting in an annual increase in pesticide usage of 10% to 20%. Spinosad has a unique mode of action, involving nicotinic acetylcholine [11] and is highly toxic to Lepidoptera [12]. Similarly, Cypermethrin is both contact and stomach poison [13].

There are many alternatives control to insect pests, use of botanical pesticides, and microbial and biocontrol agents. These biorational or low-risk pesticides and other soft chemical pesticides are being used for eco-friendly control of insect pests. Environment-friendly pest control doesn't mean inadequate insect control; instead, it is everything about Integrated Pest Management. Now days locally made botanical pesticide (Jholmol) has been used to control pests and diseases of the vegetable crop in Nepal. Bio pesticides derived from the natural product of living organisms including bacteria, viruses, fungi, and plants, which are used to control the pest population. The details of these bio-rational pesticides as well as their efficacy are not tested yet. Keeping the above point in view, the present investigation was carried out to evaluate the efficacy of botanical and biological pesticides as compared with chemical pesticides in controlling major insect pest of cabbage.

Materials and Methods

Site selection and research site

The research was conducted in Baitadi district which lies in the mid hills of Sudurpaschim province. The research was carried out in the research field of Gokuleshwor Agriculture and Animal Science College (GAASC). The research field was previously planted with main season rice. The site was surrounded by wheat fields about 10 meters apart. The longitudinal layout of the field was oriented towards the east-west direction. It is located at an elevation of 700 meters above mean sea level and lies between 27^0 30'' North latitude and 83^0 27'' East longitude. A visual display of a map of Nepal indicating the research site is shown in Figure 1.

Land preparation and intercultural operations

The hot nursery bed of size one square meter was prepared one month before transplanting. The seed was purchased from the local Agro-vet of Gokuleshwor, Darchula, Nepal. The land was prepared in October by plowing with the help of a power tiller. After 15 days, the field was again ploughed twice with the help of a mini power tiller followed by harrowing and leveling. Farmyard manure was applied at @13 kg/plot FYM during land preparation. Transplanting was done manually by maintaining row to row distance of 50-

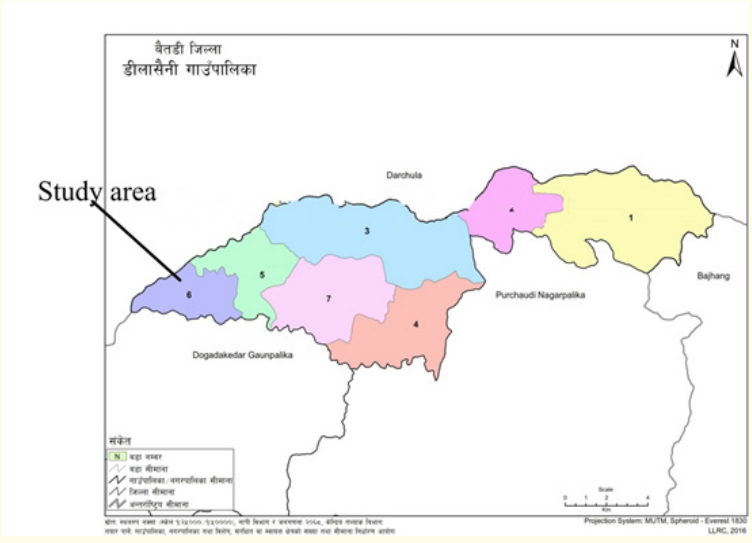

Figure 1: Map showing experimental site.

50 centimeter (cm) and a plant to plant distance of 50-50 cm. Crop management practices like timely weeding, irrigation and fertilizer application done for the proper growth and development of cabbage. The recommended dose of fertilizer NPK was @12:9:4 kg/ ropani. The full dose of phosphorous and potassium and half dose of nitrogen were applied as a basal dose 7 days before transplanting. The remaining half dose of nitrogen was applied 15 days after transplanting by making a circle around the seedlings. A recommended dose of farm yard manure 1000kg/ropani was incorporated in the soil manually during land preparation. Mix micronutrients containing a high percentage (%) of boron were supplied for facilitating the proper growth of cabbage. It was supplied as a basal application at the time of field preparation i.e., 2 days before transplanting of the seedling. The first irrigation was done after the transplanting of the seedlings. Firstly, irrigation was done regularly for one week. Sprinkler irrigation was given for 25 days at 5 day intervals to the cabbage after seven days of transplantation. Weeding was done in the interval of 20 days.

Experimental layout

The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications and seven treatments. Different botanical pesticides, biological pesticides, and soft synthetic pesticides were assigned as treatment and each treatment was replicated three times. The total area of the experimental field was 144 square meter. The area was divided into three blocks representing replication and each block was divided into seven small plots of size 2.5×2.5 meter (m). The distance between each block was 1m and the distance between each plot was 0.5 m. Each plot consists of 5 rows and the distance between each row is 50 cm. Each row consists of five plants and the distance between each plant is 50 cm.

Treatment combination

The treatment details shown in Table 1.

Data collection

Data were collected with regular monitoring of the field from the date of transplanting to the harvesting of cabbage. Data were collected for the number of major damaging insects of cabbage before 1 day of the use of treatment i.e. pretreatment and after the spray treatment and then at 3 days intervals till 9 DAS. The identification of insects and counting of their population were done for all plots. The major observed insects in the cabbage field were the Cabbage butterfly, Diamondback moth, Cabbage semi-looper, and Cabbage aphid. The populations of diamondback moths did not reach a damaging threshold level, so data were recorded for cabbage butterflies, cabbage semi-loopers, and cabbage aphids. Two sprays were applied in 10 days regular intervals. Insect population was observed and data were collected from 3 DAS, 6 DAS, and 9 DAS in each treatment. Data regarding to number of infested cabbage plants, number of damaged leaves and number of holes/ leaves were recorded at 65 DAT, 75 DAT, 85 DAT and 95 DAT.

Cabbage Butterfly (*Pieris brassicae*)

The population density of the Cabbage Butterfly was recorded based on the number of larvae per plant. All the open leaves and

Treatment	Chemical/Scientific Name	Trade Name	Formulation	Dose
T1: (Botanical Insecticide)	Azadirachtin	Neem mix	0.15 EC	5ml/L of water
T2: (Synthetic Insecticides)	Cypermethrin	Super killer-10	10 % EC	2ml/L of water
T3: (Entomopathogenic Bacteria)	*Bacillus thuringiensis* var *kurstaki*	Mahashakti	2×10^9 CFU/g	2ml/L of water
T4: (Cow urine)	Cow urine	Locally collected		1:10 of water
T5: (Jholmol)	Jholmol			
T6: (Entomopathogenic fungus)	*Beauveria bassiana*	Racer	2×10^8 CFU/g	2 g/L of water
T7: (Control)				
EC; Emulsifiable concentrate, %; percentage, CFU; colony forming unit, g; gram, L; liter and ml; milliliters				

Table 1: Treatment Combination.

open heads of the selected plants were observed thoroughly and the numbers of larvae found were recorded.

Cabbage Aphid (*Brevicoryne brassicae*)

Aphids were found feeding on the leaves of plants. The actual number of cabbage aphids was counted on both sides of the leaves and on a rainy day; a large number of aphids were seen on the underside of the leaves.

Cabbage semi-looper (*Thysanoplusia orichalcea*)

The population density of Cabbage semi-looper was recorded based on the number of larvae per plant. All the leaves and open heads of the plant were observed thoroughly and the number of larvae found was recorded. On a cloudy day, they showed more activeness toward feeding on leaves and the head of cabbage.

Figure 2: Observed different insect pests of cabbage; Cabbage semi-looper (A), Cabbage butterfly (B) and Cabbage aphids (C).

Data analysis

First, the data was entered into an Excel sheet then it was analyzed with the help of the statistical tool R Studio/RSTAT. Duncan's Multiple Range Test (DMRT) was employed to determine the significant differences between the mean values at a 5% significance level.

Results

Cabbage semilooper

The effect of different treatments in control of cabbage semilooper is shown in Table 2 and mean number shown in figure 3. Before the first spray of pesticide, data recorded in pre-treatment was non-significant. There was significant number of larvae/plants at 3 DAS during the second spray. The lowest number of larvae recorded from Superkiller-10 (0.44/plant) and the highest number of larvae were recorded in Control (1.26/plant). At 6 DAS during the second spray, the lowest number of larvae was observed in Superkiller-10 (0.45/plant) and the highest in control (1.26/plant). At 9 DAS, the lowest number of larvae in Superkiller-10 (0.45/plant) and the highest number of larvae observed in Control (1.33/plant).

Cabbage butterfly

The number of cabbage butterflies observed during various treatments at different DAS is presented in Table 3 and mean number presented in figure 3. Significant effect were observed in reduction of number of cabbage butterfly larvae at 3 DAS lowest number

Treatment	Pre-treatment	Number of cabbage semi looper during first spray			Pre-treatment	Number of cabbage semi looper during second spray		
		3DAS	6DAS	9DAS		3DAS	6DAS	9DAS
Neem mix	1.15 [a]	0.82[ab]	1.00[a]	1.04 [a]	1.11 [a]	0.63 [b]	0.67 [b]	0.67 [bc]
Superkiller-10	1.04 [a]	0.78 ab	1.00 [a]	1.07 [a]	1.11[a]	0.44 [b]	0.45 [b]	0.45 [c]
Mahashakti	1.18 [a]	0.82 ab	0.85 [a]	0.85 [a]	0.93 [a]	0.59 [b]	0.63 [b]	0.59 [bc]
Cow urine	0.89 [a]	0.83 [ab]	0.82 [a]	0.85 [a]	1.11 [a]	0.67 [b]	0.59 [b]	0.71 [bc]
Jholmol	0.85 [a]	0.37 [b]	0.74 [a]	0.82 [a]	0.93 [a]	0.63 [b]	0.63 [b]	0.70 [bc]
Racer	1.04 [a]	0.67 [ab]	0.78 [a]	0.82 [a]	0.85 [a]	0.56 [b]	0.63 [b]	0.78 [b]
Control	1.08 [a]	1.19 [a]	1.22 [a]	1.15 [a]	1.33 [a]	1.26 [a]	1.26 [a]	1.33 [a]
Grand mean	1.03	0.79	0.92	0.94	1.05	0.68	0.69	0.75
SEM	0.05	0.08	0.09	0.1	0.09	0.03	0.03	0.02
CV%	20.79	35.5	32.14	33.71	27.77	27.11	24.52	21.67
LSD 0.05	0.38	0.49	0.53	0.57	0.52	0.33	0.33	0.29
F-test	NS	NS	NS	NS	NS	**	**	***

DAS: Days after spraying; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01), *** Significant at 0.1% and ns: not significantly different at 5% (P > 0.05).

Table 2: Effect of different treatments on the population of cabbage semi looper at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi.

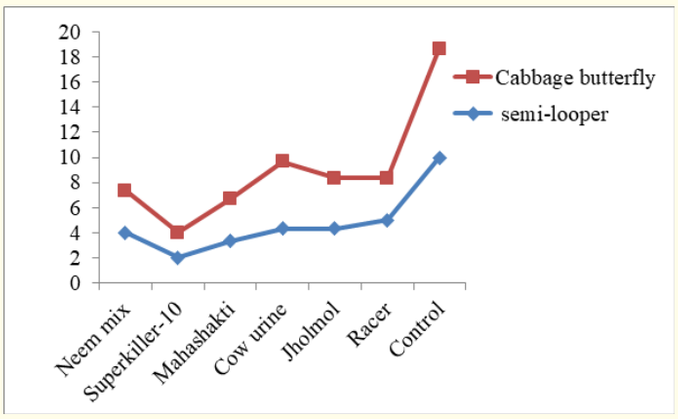

Figure 3: Number of cabbage butterfly and cabbage semi-looper observed at 9 days after second spray.

Treatment	Pre-treatment	Number of cabbage butterfly during first spray			Pre-treatment	Number of cabbage butterfly during the second spray		
		3DAS	6DAS	9DAS		3DAS	6DAS	9DAS
Neem mix	0.78 [a]	0.56 [b]	0.48 [a]	0.48 [b]	0.55 [b]	0.37 [b]	0.37[c]	0.44 [bc]
Superkiller-10	0.71 [a]	0.44 [b]	0.48 [a]	0.48 [b]	0.56 [b]	0.22 [b]	0.29[c]	0.29 [c]
Mahashakti	0.63 [a]	0.52 [b]	0.52 [a]	0.59 [ab]	0.74 [ab]	0.29 [b]	0.41[bc]	0.44 [bc]
Cow urine	0.67 [a]	0.71 [ab]	0.74 [a]	0.70 [ab]	0.70 [ab]	0.36 [b]	0.67[ab]	0.67 [b]
Jholmol	0.74 [a]	0.78 [ab]	0.71 [a]	0.74 [ab]	0.70 [ab]	0.44 [b]	0.52 [bc]	0.52 [bc]
Racer	0.67 [a]	0.59 [b]	0.56 [a]	0.59 [ab]	0.52 [b]	0.41[b]	0.41 [bc]	0.44 [bc]
Control	0.74 [a]	1.00 [a]	0.82 [a]	0.89 [a]	0.93 [a]	0.89 [a]	0.89 [a]	1.03 [a]
Grand mean	0.7	0.66	0.61	0.64	0.67	0.43	0.52	0.55
SEM	0.06	0.03	0.03	0.03	0.03	0.03	0.02	0.02
CV%	35.23	28.38	30.23	29.55	27.06	40.59	28.87	28.2
LSD 0.05	0.44	0.33	0.33	0.34	0.32	0.31	0.26	0.28
F-test	NS	*	NS	NS	NS	*	**	**

DAS: Days after spraying; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and ns: not significantly different at 5% (P >0.05).

Table 3: Effect of different treatments on the population of cabbage butterflies at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi.

of larvae observed in Superkiller-10 (0.44/plant) and the highest number in Control (1.00). At 3 DAS during the second spray, the population density of cabbage butterfly larvae was found significantly reduced, showing the lowest in Superkiller-10 (0.22/plant) and the highest in the Control (0.89/plant). Significant effects of different were observed at 6 DAS and 9 DAS. At 9 DAS lowest number of larvae observed in Superkiller-10 and highest in Control (1.03/plant).

Cabbage aphid

The number of aphids at different DAS is shown in Table 4 and mean number of cabbage aphids presented in figure 4. The lowest numbers of cabbage aphids were recorded in Cow urine (16.85/plant) and the highest was found in Control (67.92/plant) at 3 days after the second spray of treatment. Significant reduction of cabbage aphids were at 9 DAS of second spray showing the lowest in Superkiller-10 (42.19/plant) and the highest in Control (89.79/plant).

Treatment	Pre-treatment	Number of cabbage aphids during first spray			Pre-treatment	Number of cabbage aphids during second spray		
		3DAS	6DAS	9DAS		3DAS	6DAS	9DAS
Neem mix	56.32^{a}	38.80^{b}	45.77^{a}	56.22^{b}	63.41^{b}	26.00^{b}	40.85^{b}	42.57^{b}
Superkiller-10	53.90^{a}	29.11^{b}	46.96^{a}	60.04^{b}	62.37^{b}	17.68^{b}	36.00^{b}	42.19^{b}
Mahashakti	55.11^{a}	36.83^{b}	44.78^{a}	53.30^{b}	54.85^{b}	16.85^{b}	48.63^{b}	46.18^{b}
Cow urine	48.58^{a}	30.58^{b}	50.04^{a}	51.22^{b}	51.68^{b}	18.04^{b}	34.81^{b}	49.14^{b}
Jholmol	50.29^{a}	23.89^{b}	40.00^{a}	50.80^{b}	50.74^{b}	29.80^{b}	33.56^{b}	53.49^{b}
Racer	42.51^{a}	24.15^{b}	55.58^{a}	69.41^{ab}	69.57^{ab}	30.57^{b}	43.08^{b}	48.96^{b}
Control	48.86^{a}	71.37^{a}	68.48^{a}	84.15^{a}	93.54^{a}	67.92^{a}	74.62^{a}	89.79^{a}
Grand mean	50.79	36.39	50.23	60.74	63.74	29.41	44.5	50.33
SEM	1.9645	2.52	2.46	1.624	2.189	7.79	1.059	1.492
CV%	27.59	43.62	31.22	20.98	23.21	30.01	23.12	24.26
LSD 0.05	24.93	28.24	27.9	22.67	26.32	15.7	18.31	21.73
F-test	NS	*	NS	NS	*	***	**	**

DAS: Days after spraying; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and ns: not significantly different at 5% (P >0.05).

Table 4: Effect of different treatments on the population of cabbage aphids at different intervals during the first and second spray of pesticide at Gokuleshwor, Baitadi.

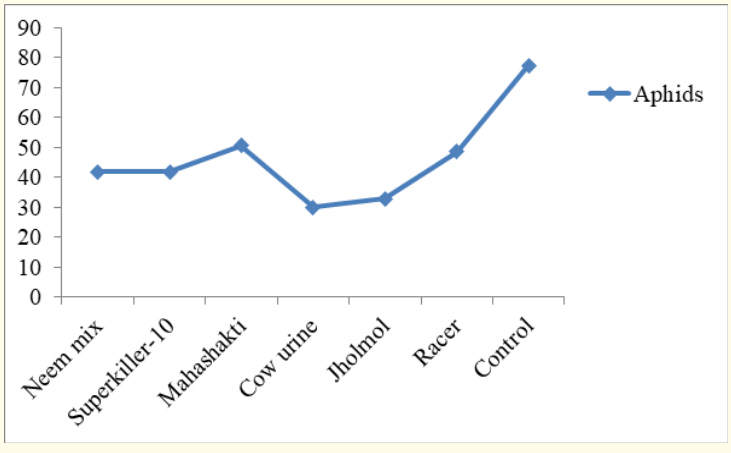

Figure 4: Number of cabbage aphids observed at 9 days after second spray.

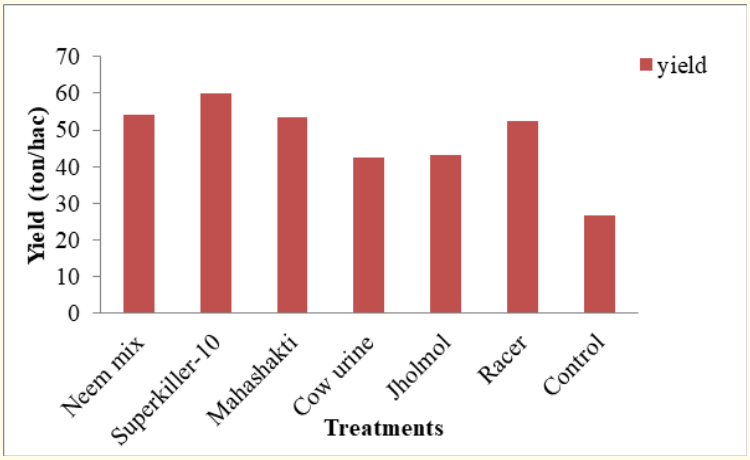

Figure 5: Yield obtained from application of different treatments.

Infested cabbage plant, number of damaged leaves and number of holes/leaves

Infested cabbage plant, number of damaged leaves and number of holes/leaves observed at 65 DAT, 75 DAT, 85 DAT and 95 DAT shown in table 5, 6 and 7 respectively. At 95 DAT, lowest number of infested plants observed in Neem mix (0.67) and Superkiller-10 (0.67), and highest number of infested plants were found in Control (0.89). At 95 DAT, lowest number of damaged leaves observed in Superkiller-10 (1.26/plant) and highest in Control (2.15/plant). Significantly reduced numbers of holes/leaves were recorded at 95 DAT in Superkiller-10 (3.15/leaves) and the highest in Control (5.11/plant).

Treatments	65DAT	75DAT	85DAT	95DAT
Neem mix	0.29 [a]	0.37 [a]	0.67 [b]	0.67 [b]
Superkiller-10	0.40 [a]	0.40 [a]	0.63 [b]	0.67 [b]
Mahashakti	0.33 [a]	0.41 [a]	0.71 [b]	0.71 [ab]
Cow Urine	0.37 [a]	0.56 [a]	0.78 [ab]	0.89 [a]
Jholmol	0.29 [a]	0.40 [a]	0.71 [b]	0.82 [ab]
Racer	0.37 [a]	0.44 [a]	0.71 [b]	0.74 [ab]
Control	0.26 [a]	0.59 [a]	0.93 [a]	0.89 [a]
GM	0.33	0.45	0.73	0.77
SEM	0.01	0.01	0.01	0.01
CV%	28.49	26.01	11.26	12.41
LSD	0.17	0.21	0.15	0.175
F-Test	NS	NS	*	*

DAT: Days after Transplanting; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and ns: not significantly different at 5% (P >0.05).

Table 5: Number of infested cabbage plant before and after the spray of different treatment at Gokuleshwor, Baitadi.

Treatments	65DAT	75DAT	85DAT	95DAT
Neem mix	0.29 [a]	1.00 [bcd]	1.55 [abc]	1.55 [bc]
Superkiller-10	0.40 [a]	0.89 [d]	1.26 [c]	1.26 [c]
Mahashakti	0.33 [a]	1.15 [abc]	1.52 [bc]	1.52 [bc]
Cow Urine	0.36 [a]	1.18 [ab]	1.66 [abc]	1.93 [ab]
Jholmol	0.29 [a]	1.18 [ab]	1.78 [ab]	1.93 [ab]
Racer	0.36 [a]	0.96 [cd]	1.48 [bc]	1.59 [bc]
Control	0.26 [a]	1.26 [a]	1.96 [a]	2.15 [a]
GM	0.33	1.09	1.6	1.7
SEM	0.01	0.01	0.01	0.05
CV%	29.03	9.39	13.53	13.38
LSD	0.17	0.18	0.38	0.41
F-Test	NS	**	*	**

DAT: Days after Transplanting; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and ns: not significantly different at 5% (P >0.05).

Table 6: Number of damaged leaves before and after the spray of different treatment at Gokuleshwor, Baitadi.

Treatments	65DAT	75DAT	85DAT	95DAT
Neem mix	1.71 [a]	2.26 [b]	3.33 [b]	3.56 [cd]
Superkiller-10	2.07 [a]	2.55 [b]	3.15 [b]	3.15 [d]
Mahashakti	1.67 [a]	2.29 [b]	3.78 [ab]	4.15 [bc]
Cow Urine	1.66 [a]	2.63 [b]	4.22 [ab]	4.52 [ab]
Jholmol	2.00 [a]	2.82 [b]	4.11 [ab]	4.15 [bc]
Racer	2.04 [a]	2.85 [ab]	4.19 [ab]	4.52 [ab]
Control	2.15 [a]	3.59 [a]	4.89 [a]	5.11 [a]
GM	1.9	2.71	3.95	4.16
SEM	0.12	0.17	0.35	0.24
CV%	18.5	15.36	15.06	11.83
LSD	0.63	0.74	1.06	0.88
F-Test	NS	*	NS	**

DAT: Days after Transplanting; GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and ns: not significantly different at 5% (P >0.05).

Table 7: Number of hole per leaves before and after the spray of different treatment at Gokuleshwor, Baitadi.

Head Weight of Cabbage and B/C ratio

Head Weight of Cabbage presented in table 8 and B/C ratio presented in table 9. The highest number of yields was obtained from the plot treated with Superkiller-10 (59.88 ton/ha) and lowest yield was obtained from the Control plot which was highly damaged by insects. The highest B/C ratio was observed with the treatment Superkiller-10 and the lowest in control. Biological insecticides used in the management of insect pests showed the highest B/C ratio than the botanical insecticides.

Treatment	Head wt.(ton/hac)
Neem mix	54.12 [ab]
Superkiller-10	59.88 [a]
Mahashakti	53.57 [ab]
Cow Urine	42.34 [b]
Jholmol	42.98 [b]
Racer	52.45 [ab]
Control	26.70 [c]
GM	47.43
SEM	42
CV%	13.66
LSD	11.53
F-Test	***
GM: Grand Mean, LSD: Least significant difference, SEM: Standard error of mean, CV: Coefficient of variance; Mean values in each column with the same common small letters are not significantly different by LDS value, *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01) and NS: not significantly different at 5% (P >0.05).	

Table 8: Head wt. of cabbage at harvesting in different treatments.

Treatment	Head wt. (ton/Ha)	Cost of cultivation	Total Return (NRs/ha)	Net Profit	B/C ratio
Neem mix	54.12	216500	811800	595300	2.75
Superkiller-10	59.88	213190	898200	685010	3.21
Mahashakti	53.57	209230	803550	594320	2.84
Cow Urine	42.98	203220	644700	441480	2.17
Jholmol	42.34	206233	635100	428867	2.08
Racer	52.45	209665	786750	577085	2.75
Control	26.7	195800	400500	204700	1.05
*The selling price in rupees of cabbage head at farm gate price was NRs. 15 per kg in Gokuleshwor Baitadi and Darchula local market.					

Table 9: B/C ratio calculation.

Discussion

Overall, the results demonstrate spraying of Superkiller-10 shows the lowest number of cabbage semi-looper, cabbage butterflies, cabbage aphids, infested cabbage plants, damaged number of leaves and number of holes in the leaves, highest head weight and B/C ratio of cabbage than other treatments. Superkiller-10 acts through both contact and stomach poison mechanisms [13]. When insects come into contact with Superkiller-10 or ingest it, the insecticide disrupts their nervous system, leading to paralysis and eventual death [14]. The findings of our experiment are similar to those reported by [13, 14, 15, 16] that Superkiller-10 was more effective compared to other chemicals in controlling the population of cabbage butterfly. Field experiment conducted for management of cabbage butterfly in cauliflower at Rampur, Chitwan concluded that insecticides like Spinosad and Cypermethrin (Superkiller-10) were more effective than Neem mix, Mahashakti, and Liquid manure at 3 DAS, 6 DAS, and 9 DAS during the third and fourth pesticide sprays [17], which is in support with our result. The Cruciferae is one of the major plant family that the cabbage butterfly freely feeds on and can severely damage these plants at all stages of growth, including seedlings, vegetative, curding, and flowering [18]. Cabbage butterfly and Cabbage semi-looper cause heavy damage in leaves and result in numbers of holes by eating rigorously and destroying the host plants [19]. Significantly, a lower larval population of the cabbage butterfly was recorded in Superkiller-10 after the third and fourth spray of different pesticides as a results, the lowest number of damaged plants, leaves, and leaf holes were recorded in Superkiller-10 treated plots [17,20] which is similar with our results. The maximum biological and curd yield was found in Superkiller-10 treated plots as compared to the Neem

mix, Mahashakti, and Liquid manure treated plots [17,20], which is in support with our results. Similarly, mortality percentage of cabbage butterfly instars higher in the chemical pesticide Superkiller-10 than in the neem-based product [15]. The cauliflower growing farmer can use Jholmol and Racer for cost-effective control of aphids [9]. The smallest dose of 60 g a.i./ha of cypermethrin 10 AF was significantly effective in the reduction of a pest population compared to the untreated check. The order of bio-efficacy against aphids was acetamiprid 20 SP (56.12%)>indoxacarb 14.5 SC >cypermethrin 10 AF >cypermethrin 10 EC whereas the order of bio-efficacy of these insecticides in case of diamondback moth was cypermethrin 10 AF >cypermethrin 10 EC >indoxacarb 14.5 SC >acetamiprid 20 SP [21]. Our result shows that a lower B/C ratio of Neem mix than synthetic pesticides. Even though Superkiller-10 treatment results in highest yield and favorable cost-benefit ratio than environment friendly treatments such as jholmol and Racer. The chemical treatments have highest B/C ratio than botanical treatments, Jholmol and Cow urine but they showed potential for effective and long-term substitutes for chemical insecticides [22]. Highest B/C ratio and curd height was found in Supperkiller-10 sprayed plot [17], which is similar with our result.

Conclusion

Cabbage butterfly, cabbage semi-looper, and cabbage aphids are the most important pest of cabbage in the winter season at Gokuleshwor, Baitadi. These pests can cause significant biological and economic loss in cabbage. Superkiller-10, a chemical based pesticide is best for reduction of insect population and to obtain better yield. Neem mix, Mahashakti, Racer and Jholmol also showed potential in management of insect pest in cabbage and they would be the best alternatives to chemical based pesticides for eco-friendly, sustainable and cost-effective management of insect pests of cabbage.

Recommendation

Testing of different doses of eco-friendly pesticides Neem mix, Racer, Mahashakti and Jholmol is recommended for further research.

Conflict of Interest

The author declares no conflict of interest.

Acknowledgments

The authors are thankful to Plant Protection Department, Faculty of Agriculture, Gokuleshwor Agriculture and Animal Science College (GAASC), Tribhuwan University for providing land for this research. The authors are not aware of any funding.

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